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NEGLECTED DETAILS IN BRICK PAVEMENT CONSTRUCTION

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Neglected Details in Brick Pavement Construction.

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WHEN THE Secretary of this Association asked me to present a paper at this convention I objected on the ground that I had nothing to say that would be either interesting or of advantage. He explained that the members of the Association held that they promoted the private interests of paving brick manufacturers to the best advantage when they were helping to educate the public as to the best and most economical methods of constructing brick pavements, and that I was desired to present a paper calling attention to any points which I thought would improve the quality or reduce the cost of ordinary brick pavements. The writer freely adimts that some of the most important advances in brick pavement construction have been the results of investigations conducted by this Association and of papers read at its annual conventions, and the writer also freely admits that the benefits of these investigations and of these papers have been greatly enhanced by the liberality of this Association in disseminating this information. Therefore the writer is very glad to contribute his mite toward the improvement of brick pavement construction, particularly since a brick pavement possesses many of the most important requisites of an ideal pavement.

The outline of the method of constructing a brick pavement is so generally understood as to make it unnecessary in this paper to give a description of the several operations, and therefore attention will be centered upon those parts of the work that seem to have received the least attention, or at least seem most to need attention. The subjects to be considered will

be taken up approximately in the order in which they occur in the work of construction.

—Width of Pavement—

In many cases a considerable part of the money spent for a pavement is wasted by making the pavement wider than is necessary. A narrow pavement not only costs less to construct, but also costs less to clean and to sprinkle. Of course, except for the cost, the wider the pavement the better; but length is more desirable than width. An excessive width is a needless expense, and delays or wholly prevents the getting of any pavement at all; and hence one help towards securing pavements is to make them only wide enough to accommodate travel.

It is not unusual to find residence streets in small cities, without street car tracks, with pavements 36 to 40 feet wide. The only travel over such streets consists of private carriages and the delivery wagons that supply goods of various kinds to the residents. All the pavement that such streets really require is a width such that two vehicles may pass at reasonable speed and with ordinary care without interference. A width of 18 feet affords sufficient room for a vehicle to pass when another is standing on each side of the pavement—a rare occurrence;—and therefore it appears that a pavement 18 feet wide, or at most 20 feet, is sufficient for the less frequented residence streets. Therefore any money spent to construct a wider pavement is not only absolutely thrown away, but the cost of sprinkling and sweeping is also needlessly increased. Further, narrowing the pavement increases the lawn space, which not only improves the appearance of the street, but also gives additional space in which to place gas pipes, water pipes, etc., and thereby prevent the tearing up of the pavement, which is always a damage. The only objection to a very narrow pavement is the difficulty of turning a team on it. The seriousness of this objection depends upon the construction of the vehicle. Many delivery wagons, express wagons, etc., may be turned easily on an 18-foot pavement. If occasionally a vehicle is compelled to go to the corner to turn, or even to drive around the block, the inconvenience is not very serious, and it is so infrequent as not to justify any considerable expense to prevent it. If the block is long, or if the objection to some vehicles being compelled to drive around the block is considered important, then it is much cheaper to construct a turning place near the center of the block than to build an additional strip of pavement the entire length of the street.

The cost of pavement, per square yard, is practically independent of its width, and therefore the reduction of the width of the pavement on residence streets from 36 or 40 feet to 18 or 20 feet will save nearly 50 per cent. of the cost, and if the cost can be reduced one-half, the number of paved streets will be increased much more than proportionally.

It is not wise to take time to discuss the width of pavements on residence streets containing car tracks, nor on business streets; but a little investigation will show that in many cases the pavement is considerably wider than has been found entirely satisfactory under similar conditions. The views here express not mere theory, but are supported by experience in a number of cities. In recent years there has been a marked tendency, in the middle West at least, to reduce the width of pavements on residence streets and on business streets in the smaller cities. Attention is here called to the matter because far too often the width of the pavement is made a fixed proportion of the total width of the street regardless of the real needs of travel. This is only one of the many ways in which some municipalities suffer from the lack of more competent engineering service—the loss frequently being many times the saving.

Subgrade

It is unnecessary to say that the subgrade is the ultimate support of any pavement, and that both the cost and the efficiency of a pavement depends upon the supporting power of the soil upon which it rests. There are only two ways of increasing or supplementing the supporting power of the subgrade: (1) by underdrainage, or (2) by constructing a pavement that will distribute the concentrated load of the wheel over a considerable area of the subgrade. Usually the former is both the cheaper and the more effective. Tile drainage is cheap to construct, is certain in action, and costs nothing for maintenance. With all soils, except clean dry sand, the cost of both the construction and the maintenance of the pavement could be materially decreased by proper underdrainage.

Not only should the subgrade be properly drained, but it should be thoroughly rolled to compact the surface and also to reveal any soft spots. Usually just before a pavement is to be constructed, the street is dug up to lay sewers, and water and gas pipes and to connect these with the private property; and almost universally the trenches are refilled in such a manner that great care and skill are required to construct a pavement which will not ultimately settle over the trenches, much to the damage of the pavement and the disfigurement of the

street. It is always specified that the subgrade shall be thoroughly rolled; but it needs only a casual inspection of the pavements of any city to show that this is seldom done in a manner to prevent settlement. The cheapest and surest remedy to prevent such settlement, is to properly refill the trenches; but usually this indifferently done, owing to the ignorance or the carelessness of the proper municipal officer, and as a consequence the remedy of this defect is left to the paving contractor. The subgrade should be rolled both longitudinally and transversely with a steam roller weighing not less than five tons. If the street is rolled in only one direction, only one set of trenches will be compacted. The subgrade can not be rolled transversely with a horse roller; and besides the horses' feet tear up the subgrade nearly as much as the roller compacts it, particularly when the rolling is almost completed. The roller should pass over the surface several times to settle the filling into the trenches and also to compact the surface by the kneading action of many passes of the roller. Unfortunately the specification requiring the use of a steam roller adds somewhat to the cost of a pavement, since that implement is expensive in first cost and also in maintenance, and since ordinarily it can be used only a comparatively short time each year; but its use is believed to be worth its cost, particularly if the trenches were not properly back-filled.

—The Foundation—

Brick Foundation. The first brick pavements were laid on a foundation consisting of a layer of gravel and a course of brick laid flatwise. This form of foundation has been all but abandoned for two reasons: First, because some other form is usually cheaper; and, second, because of the lack in the past of proper precautions in laying the foundation. There have been two defects in constructing this form of foundation. First, the gravel is neither spread nor consolidated uniformly. This point will be considered fully later. The second defect consists in laying broken bricks with their broadest side up, and hence the space below is not well filled while the cushion coat is being spread, and consequently after the pavement is completed the cushion coat works into these cavities and permits the surface of the pavement to sink. If all broken brick are laid on the broad side and care were taken thoroughly to fill the joints while laying the cushion coat, this form of foundation will give satisfaction, even though the lower course of brick be quite inferior. The writer is quite familiar with a piece of such pavement laid on a very

unfavorable subgrade, but with proper precautions in the two respects mentioned above, which for ten or fifteen years has given entire satisfaction and has as good a surface as adjoining pavements on a concrete base, even though the latter are on a more favorable subgrade and carry less travel. This pavement illustrates a rule of construction that can not be repeated too often, viz.: No good brick pavement can be constructed without proper attention to all details.

Concrete Foundation. Nowadays it seems to be the general belief that a 6-inch concrete base is necessary for a brick pavement; at least, this foundation is used indiscriminately for business and residence streets, and is used indiscriminately also on the stiffest soil and on the softest. A 6-inch concrete foundation is ordinarily used under an asphalt pavement, which is a more or less flexible layer from 2 to 3½ inches thick; while the same thickness of concrete is ordinarily used with a brick pavement having a cement filler, which is a very rigid layer from 5 to 7 inches thick. Is there any evidence that the foundations of asphalt pavements are generally weak?

An engineering journal recently contained an account of a test of the supporting power of an asphalt pavement, made by hauling over it a truck weighing 22,300 pounds and giving a pressure of slightly over three tons on two wheels having tires four inches wide. The foundation consisted of a 4-inch layer of natural-cement concrete mixed in the proportion of one part cement, two parts sand, and five parts crushed stone. The asphalt wearing surface was two inches thick. The subgrade consisted of "soft wet clay which has been much disturbed by many trenches for sewers and for water and gas pipes." The pavement had been in use twelve years when tested, and had shown no signs of failure. "The above load was hauled over this pavement from end to end and produced no effect upon the pavement except to make a slight depression in the asphalt where the wheels stood for half an hour, the day being warm."

Does this prove that the concrete foundations of brick pavements are generally needlessly thick? Surely if four inches of concrete over soft clay and under a 2-inch asphalt wearing-coat can support such loads, six inches of concrete is surely needless under brick pavement with cement filler.

Let us consider this question from another point of view. There are three and only three reasons for constructing a pavement, viz.: (1) To secure a smooth surface for ease of cleaning and to decrease tractive resistance; (2) to secure an impervious roof to prevent rain water from softening the subgrade; and

(3) to interpose a layer that shall distribute the concentrated load of the wheel over so great an area of the subgrade that it can safely support the load without depression. For the moment, we are not concerned about the smoothness of the surface, and hence nothing will be said here about the first reason for constructing a pavement. The wearing surface of a brick pavement is practically impervious whether sand or cement filler be used, and consequently a concrete foundation is not necessary to secure a water-tight roof to protect the subgrade. Therefore, the concrete foundation of a brick pavement acts only to distribute the load of the wheel over the subgrade. The concrete distributes the load by virtue of its ability to act as a beam; and this property is due to the cement which the concrete contains. If there were no cement in the concrete, the layer of gravel or crushed stone would distribute the concentrated load of the wheel over a considerable area. The pressure of the wheel is transmitted downward in diverging lines; and if the point of contact of the wheel is considered as the apex of a cone having its base on the subgrade, it may be assumed that the load of the wheel is distributed nearly uniformly over the base of this cone. It is unwise to attempt here to go into the mathematics of the subject further, but the efficiency of a layer of broken stone in distributing a concentrated load is proved by the fact that, under favorable circumstances as to soil and drainage, 4 inches of broken stone has successfully carried considerable travel, while 6-inch macadam roads are quite common in a number of States. If 4 or 6 inches of macadam without any other pavement will carry travel, the same thickness will certainly make a good foundation for a brick pavement under ordinary conditions—particularly if a cement filler is used, since the filler gives the course of brick a considerable transverse strength, as will be discussed later. The writer recently saw a piece of brick pavement with sand filler which is laid directly upon the black loam of the Illinois corn belt which for six or eight years has carried the heaviest travel of a city of three or four thousand inhabitants and which is still in good condition. A tile drain was laid at each side of the street, the subgrade was well rolled, and the paving bricks (not blocks) were laid upon a layer of sand and small gravel only one or two inches thick. Probably no small part of the success of this pavement is due to the fact that a prominent and intelligent and successful local business man acted as inspector. The writer does not advocate the general adoption of this form of construction; but cites this case to show what can be done by

intelligence and care, and to prove that a layer of concrete is not always necessary. A needlessly expensive form of construction is not only money wasted, but deters the construction of other pavements.

Not infrequently pavements having a concrete foundation are found which have settled over trenches. Does not this prove that the ordinary concrete foundation is not strong enough? No, it simply proves that the foundation over the trench is not strong enough. There are two remedies for this condition of affairs. Either consolidate the filling in the trench better by rolling or tamping as described above, or make the concrete thicker over the trench. The first is cheaper and more scientific. In no case is it justifiable to thicken or strengthen the foundation over the entire street simply because trenches occupying from 5 to 10 per cent. of its surface may not have been properly back-filled.

Before considering substitutes for concrete foundations, let us examine the concrete a little further. Formerly it was the custom to use a rich natural-cement concrete, because it was cheaper than a Portland-cement concrete of equal strength. A few years ago nearly all the Portland cement used in the country was imported, while now nearly all of it is of domestic manufacture; and, further, it is not only home-made, but it is both better and cheaper. Although natural cement is marvelously cheap, a concrete of a given strength can be made cheaper of Portland than of natural cement. Experiments made at the University of Illinois show that a concrete composed of one part Portland cement, eight parts of coarse sand or fine gravel, and eight parts of screened or broken stone was considerably stronger in compression and also in bending than a concrete composed of one part natural cement, three parts of the same sand, and three parts of the same broken stone. These proportions have been practically tested in the construction of half a mile of pavement the past summer with the greatest satisfaction to all parties concerned. Prices vary greatly with the locality, but in most, if not in all, cases Portland-cement concrete is cheaper in proportion to strength than that made with natural cement.

Before dropping the subject of concrete foundations, a few words should be said in condemnation of the quite general practice of leaving the upper face of the concrete needlessly rough and irregular, with loose stones strewn over the surface. To secure a uniform surface for the pavement, the cushion coat should be of uniform thickness, and hence the top face

of the concrete should be practically parallel with the surface of the finished pavement. Also any loose stones on top of the concrete causes the brick to be broken during the rolling and produces inequalities in the surface of the finished pavement. Both of these effects can be eliminated without appreciable expense by a little care.

Finally, although brick pavements are usually laid upon concrete foundations, it by no means follows that a concrete base is either necessary or most economical. A course of gravel or broken stone, when properly laid, will make as good a foundation as a layer of concrete, and in some cases is cheaper. Further, less skill is required with a gravel or broken stone foundation than with a concrete foundation. Those who have made cuts into concrete pavement foundations report that in a majority of cases the concrete is no better than a layer of broken stone without cement, due apparently to carelessness, or inefficiency, or dishonesty in the construction. The process of placing gravel or broken stone is simpler, and therefore there is less danger of inferior work; and the gravel or broken stone requires less hand labor, which is an advantage to contractors in these days of inconsiderate demands of laboring men. As to whether concrete, gravel, or broken stone should be used for the foundation in any particular case depends upon local prices and the local conditions; and right here is where the city needs engineering advice of a high order, for a single word in the specifications may add hundreds of dollars to the cost of the work without any return. It is more scientific and usually more profitable to give time to the consideration of the specifications beforehand than to be higgling with the contractor afterwards.

Now, a few words, only a few, about foundations that may be substituted for concrete.

Gravel Foundation. A gravel foundation for a pavement is constructed substantially as a gravel road. It is customary to dump the gravel upon the subgrade directly from wagons, and then to level off between the piles with shovels. By this process the lower part of the original piles is much more compact than the space between the piles; and rolling does not materially lessen the inequalities, since the roller, being a cylinder of considerable length, rides upon the top of the piles and does not compress the gravel between them. The result is that soon after the pavement is completed, the natural settlement of the gravel foundation causes the surface to be full of depressions. The better and cheaper method is to level off the piles with a scraping road-grader, and then thoroughly harrow the gravel

with a long-toothed harrow, after which the foundation should be rolled. For the best results, the gravel should be spread in layers not more than three or four inches thick. Brick pavements upon gravel foundations laid by this method have shown no depressions after many years, while those constructed with the utmost care by the preceding method with the same gravel on the same soil have been full of holes. This is another example showing that cheaper materials and proper methods intelligently applied give better results than expensive materials improperly used.

Broken-Stone Foundation. A broken-stone foundation may be constructed somewhat as a macadam road. If the rock is soft or contains much fine material as it comes from the crusher, it should be screened to take out all dust and most of the pieces up to say ¼-inch in greatest dimensions. The broken stone may be hauled to the street in wagons, and dumped upon the subgrade. It may be spread by hand with forks or rakes, or it may be spread with a scraping road-grader, the latter method being the cheaper. In spreading the stone care should be taken that the several sizes are not separated too much, and that the piles on which the stone was dumped from the wagons are not left too high. The layer of stone should be rolled until the individual stones do not move as one walks over the surface, or until the surface stones are not easily kicked out with the foot. After the completion of the rolling, the surface of the broken stone should be impervious to the sand to be used in the cushion coat. With most stone this condition will be secured by the crushing of the top layer of the broken stone during the rolling; but if there are spots that are porous, throw on a few shovelfuls of fine stone and roll again. If the stone is hard, it may be necessary after the rolling is nearly completed to apply a thin coat of finer or softer stone. Of course the top of the foundation should finally be left smooth and of proper grade and crown.

The rolling required with either a gravel or broken-stone foundation can best be done with a steam roller, which is only an additional reason for specifying that the subgrade shall be rolled with a steam roller. Although it is a little out of place here, this is the most convenient place to say that a steam roller is also much better than a horse roller for rolling the brick. If the subgrade, and the gravel or broken-stone foundation, and the brick are all rolled with a steam roller, the cost of rolling any one of these is materially lessened, since the roller is thus used a greater part of the time.

—The Cushion—

Little need be said about the cushion coat. The sand for the cushion should be, and usually is, fine; and therefore it is desirable that it should be uniformly dry, since a very small per cent. of water increases the volume of fine sand to a surprising degree, and consequently when the wet spots dry out the pavement will show a depression.

It is generally conceded that the cushion coat can be surfaced best by drawing over it a template reaching from curb to curb or from curb to a screed bedded in the middle of the street. Some contractors use a hand lute run upon screeds bedded comparatively close together; but this method does not give as good results as the longer template, owing to the difficulty of properly bedding so many screeds.

—The Brick—

Largely through this Association the standard of paving brick is nearly all that can be desired; and through the efforts of the individual members of the Association good paving brick can be had in nearly all localities at reasonable prices. The writer firmly believes that the manufacture of paving brick is conducted with greater skill and has reached a higher degree of perfection than any other part of the work connected with the construction of a brick pavement. Doubtless there will always be need to exercise care in selecting brick of uniform quality, but that need is steadily growing less year by year.

However, there are two particulars in which the writer believes that the practice of some brick manufacturers could be changed with advantage to the pavement. One of these is the rounding of the corners. It is possible that the rounding of the corner was introduced in part at least to decrease the loss while being tested in the rattler, but the round corner surely makes the pavement rougher. It is a disadvantage also in that it gives a thin edge to the joint filling, which causes it to crumble and chip off. The round corner is more objectionable with a cement than with a sand filler.

Some paving bricks have grooves in the flat side, apparently to give the joint filler a better hold. Obviously such grooves can be of no advantage with a sand filler, and some experiments to be referred to presently seem to indicate that they are not necessary with a cement filler. The grooves may give the filler a little freer entrance to the joint, but this effect is not great and is not needed; while the virtually wider joint is a disadvantage. But the chief objection to the grooves, particularly

when they run lengthwise of the brick, is that they cause the brick to spall off from the top surface down to the groove, probably owing to the blows of the toe and heel calks of the horses' shoes. In all the grooved brick that the writer has seen this is a serious defect.

—The Joint Filler—

Cement grout is the best material with which to fill the joints, and the report of this Association as to the method of applying this filler leaves nothing more to be said on that subject.

It has long been recognized that the chief advantages of a cement filler was that it protected the edges of the brick from spalling off; but there is another advantage that is not so generally recognized. Experiments conducted at the University of Illinois show that if a Portland-cement filler is applied in the manner specified by the committee of this Association, the layer of brick becomes a beam with approximately the same resistance to bending as a 6-inch layer of the natural-cement concrete ordinarily used in a pavement foundation.

The fact that the cement filler adds greatly to the rigidity of the layer of brick does not rest alone upon a single series of experiments. It is well known that the expansion of a brick pavement with a cement filler causes it to be lifted up from the foundation, as is proved by the rumbling sound produced by a loaded wagon going over the pavement. A little investigation will show any one that the brick can not act as a true arch, but that the layer must bend under the load and touch the foundation at certain points. That the layer of bricks will thus act proves that it has a considerable resistance to bending, *i. e.,* that it acts as a beam as well as an arch, or more properly, that the layer of brick with a cement filler acts as an elastic arch.

The above experiments show that the cement filler adds as much rigidity to the pavement as does the ordinary concrete foundation; and shows also that if a certain foundation is strong enough with a sand filler, it is substantially twice as strong with a Portland-cement filler. Again, if a brick pavement having a sand filler and a 6-inch concrete foundation is sufficiently strong to carry the travel, a pavement with cement filler and a 6-inch foundation of broken stone without any cement will also carry the travel.

A little computation will show that the cost of the cement filler is about the same as that of the cement in the usual concrete foundation. Therefore, it would apparently be better economy to employ the cement in the joint filler than in the con-

crete foundation, since in the former case the cement gives rigidity and also protects the edges of the bricks from chipping; while the cement used in the foundation gives only rigidity. The practice of using concrete foundation and cement filler with a brick pavement has gradually grown up without any careful consideration of the fundamental principles involved. The reason is not difficult to find.

In the first place city governments far too often select as city engineer a local man acceptable to the dominant party, or to the controlling element in the party, without much regard to his fitness to plan and execute large public improvements with economy and efficiency; and, as before remarked, his incapacity to grasp the fundamental principles may cost the municipality in a single improvement may times the annual salary of a really competent engineer. In the second place, it is too much the custom for one city to copy the specifications of another without due regard to the difference in conditions. And last, but not least, pavements are generally designed by engineers working upon a salary without the stimulus of individual financial interest or of competition; and hence this branch of engineering is much behind others in point of economy and efficiency. Most of you have doubtless read how American bridge engineering absolutely leads, yea even outdistances the world in India, in Australia, in South Africa, and in Egypt. American bridge building has reached this degree of excellence through the application of the principle of competition in design and manufacture. European countries have long had abundance of competition in manufacture, but have not reached even a fair degree of excellence in bridge building; for when the bridge is designed its cost and efficiency is already fixed within narrow limits. In this country we have competition in the manufacture of pavements, but none in their design; and hence in the matter of pavements most of our cities are comparable to European countries in bridge building. American practice in pavement construction will not be greatly improved until municipalities demand a higher order of engineering ability. The writer does not want to be understood as saying that there are no really competent city engineers, for there are many such; but he does claim that there are far too many who lack the thoroughness of knowledge and the breadth of view to effectively and economically conserve the best interests of the municipality in the construction and the maintenance of its pavements. But a discussion of this question would lead us too far afield.

—Conclusion—

In conclusion, permit a brief summary. Attention has been called to the width of pavements, in which it is believed that the construction of all forms of pavements may be greatly cheapened without materially decreasing their usefulness. Attention has been called to several matters wherein the efficiency of a brick pavement may be greatly increased without much increase in its cost. Again, attention has been called to a few particulars in which the cost of a brick pavement may be considerably decreased without in any way decreasing its usefulness or efficiency.

If the members of this Association approve any of these points, it is hoped that they will use their influence in securing the changes proposed; and it is believed that by so doing they will thereby aid in the general advance of municipal life, and at the same time materially increase the demand for brick pavements—a form of pavement admirably adapted to many of the streets of the great cities and the only high-class pavement available for the most of the smaller cities. (Applause.)

Brick Pavements—General Discussion.

C. C. Barr, Streator, Ill.: Mr. President—I move a vote of thanks be extended to Prof. Baker for the very excellent paper on brick pavements.

Motion seconded and carried unanimously.

Prof. Baker: Gentlemen, I feel myself highly honored.

Mr. O. N. Townsend, Zanesville, O.: I would like to make one comment on this paper that is of interest to the public, that is in regard to a four-inch concrete base. I have always felt, being a contractor as well as a manufacturer, that four inches is all that is necessary instead of six, and the paper has demonstrated that such is the case. I think we should use our influence to draw up specifications for a four-inch base and a Portland-cement filler. I would also like to state that a less rounding of the corners is also advantageous.

A Member: In listening to this paper the thought occurred to me that this Association should not keep this paper to themselves, but should have it scattered broadcast over the country. You can all say what you please, but you have got to advertise. You have got to let your goods be known. You have got to let the people know what the best thing is, and if it is true that a four-inch crushed-stone foundation is good enough to put the brick on with a cement filler and produce a first-class pave-

ment, it means a great reduction in the price of a first-class pavement. It means the popularity of brick pavement over asphalt. In our city we have what is known as a ten-year guarantee. I understand that 75 cents per yard is added to the price of asphalt for the purpose of taking care of the guarantee, so the citizen pays 7½ cents per ward in advance. Count up the interest and you see what they pay. Now, it is a question whether they ever get value for their 75 cents. Just as soon as a corporation as strong as the asphalt company find out they have the best of you, they show their hand and say, "Go on with your guarantee, and see where you get off." There is no question in my mind but that there are only two permanent pavements—granite block and brick. You all know that granite is the most durable pavement made, yet its expense precludes its use on the various streets in our city. Our city is peculiar in one respect. You have here in Cincinnati, a city where you have five mules hauling what one team will haul in the city of Chicago. The result is that the wear and tear on the pavements of the city of Chicago, as two would be compared to five. In fact, two horses or mules will pull in Chicago what you would need five for here in Cincinnati. So a pavement must be designed to take care of that traffic, and of course the load falls on the taxpayers. You gentlemen in the Association must be the means of advancement that will help the taxpayer out. You have experience and you meet year after year, and if you don't do anything else but meet in pairs and couples and groups and compare ideas, you are bound to receive the benefits of this Association, to receive the benefits of the experiences of the men from all over these United States, and the result is that you are better informed on this proposition than any single man in any single city in the United States can be. I recently picked up the specifications that are used in Terre Haute and read them very carefully. I consider them very excellent specifications. In many cases ignorance is the cause of not having better pavements. There are some cases where wisdom is the cause. (Laughter.) I mean that sometimes some particular official is extremely wise and knows how to make it benefit some particular pavement, but I consider that the exception, not the rule. So far as I am personally concerned—I suppose it is due to the atmosphere and surroundings and my associations—I believe that a brick pavement is the best pavement, and I believe this Association should send that paper of Prof. Baker's broadcast throughout the country, and see that a sufficient number of the pamphlets are sent to the taxpayers that they may see what a good pavement is.

There is no reason why under the present system in our city, the people cannot insist upon anything they want. All they have to do is to know that the thing is right and then insist upon having it done, and no engineer will dare to stop it. It is the only thing you can hope for. It is the only way you can hope to have a pavement that will be a credit to the brick men and put the asphalt trust out of the business. (Applause.)

D. V. Purington: I think the Board of Local Improvements in Chicago are beginning to get their eyes open. I would a great deal rather have a sand filler than a tar filler. There was a street put down in Chicago some eighteen years ago of Ottawa brick, 12x4x5, and some of them were taken up some time ago and were as good as when put down. The first brick pavement put down since I have had anything to do with brick pavements was a two-course pavement, one course on the flat and one on edge. That was put down in the spring of 1893, two blocks on Lake Avenue, from 35th to 37th. There has not been a cent of repair or any changes made in the street, and the brick are as good as when put down. They were put on sand. I do not think I could say the same thing if they had been on a clay subsoil. That is one reason why I do not believe that any set of specifications can be made that will fit all the existing conditions, and that is where engineers fail. Possibly some engineer in a flat prairie town would see that pavement, and would want to put down the same thing, and it would be practically a failure, especially if he did not get his drainage right. I think the same remark applies to Prof. Baker's criticisms, if they might be so called, on engineers. A set of specifications for a heavy business street in a large city must necessarily require much better work, and I think a heavier foundation than in small towns. I think that goes without saying. Yet, a set of specifications adopted by some well-known engineer of good standing is likely to be adopted by a small town bound to follow in his footsteps. This is one of the things we must educate the people to see the foolishness of. There is so little in that paper to criticise and so much to praise that I think when Mr. Randall gets out his pamphlet and notifies the paving brick manufacturers what the bill is, there will be little doubt but that it will be settled 50 cents on the dollar at any rate. (Laughter and applause.)

W. P. Blair: It is a fact generally admitted by our competitors. Even the asphalt people say we make a good brick, that it is probably a fact that it will last a long time, but that it soon becomes a rough, unsatisfactory, cobblestone surface over which you can not ride for pleasure. We have made brick, all of us, and

we have made them right, and for the past three or four years we have circulated throughout this country, from one end to the other, a set of specifications to which no man can take exceptions, unless with a view in his mind of cheapening the street. I watched closely Prof. Baker's paper from beginning to end and I do not think I can take exception to one single thing in it, but we must have a little more skill in carrying out these specifications. If Prof. Baker were to stand over or oversee the construction of a brick street I doubt not it would be right and last a long time, a great number of years, even if it had no foundation under it at all. The cross-breaking strength of a vitrified brick in size 2½x4x8¾ is over 3,000 pounds, and it don't need a foundation. I know myself that one of the best brick streets in our town was constructed with the ditches unfilled or depressed as described by Prof. Baker, and it stands there to-day with but one broken point from one end of the street to the other, and that broken place is not over three feet in diameter. The strength of the brick street, or arch or beam, as Prof. Baker describes it, has held that street up, and there passes over it 3,000 to 5,000 teams every day of ten hours, and has for over thirteen years. In his book on Roads and Pavements, you will find that Prof. Baker says the wear on that pavement is almost imperceptible; it does not exceed from 1-32 to 1-64 of an inch in thirteen years, and in a few places there is no foundation under it of any character. I have here a little specimen of brick street that has been down in the street under heavy traffic for eight years before it was taken out. The brick are of the cheapest kind we manufacture, plain, wire-cut and ordinary size brick, filled with cement. The wear on that street is imperceptible. It has not yet been down long enough to show any wear, and probably will not show any for seven or eight years to come. I want to allude to the guarantee clause of which Mr. Brennan spoke. I care not what the traffic is, build the streets right, following out the specifications as laid down in Prof. Baker's paper, and you will not ask a guarantee from any brick street contractor or manufacturer. We have town after town where we get construction like that that have eliminated from the brick people all idea of a guarantee for the maintenance of a brick street. Brick street constructed after the specifications given in that paper out of any one of fifty different brick made in this country will last on any street in Chicago fifty years. I care not what the town, nor the size. I must take exception to Mr. Brennan's remarks about a granite street. We do not know that the granite street is the best street, nor is it the most durable. (Ap-

plause.) The cross-breaking strength of a vitrified brick is 4,000 pounds, and the best piece of granite of like size you can get in this country is but 2,900 pounds. I mean the cross-breaking strength. That is, by a sharp angle resting under the brick one-half inch from the end, as they are tested in St. Louis, and a like angle underneath the opposite end, and have a knife coming down in the center and on top. A great majority of these brick will stand 5,000 pounds, and you know granite will not stand much more than half that.

A Member: What is the crushing strength?

Mr. Blair: It is about as two to one in favor of the brick. (Applause.) There is one other point in regard to these granite block. I favor the organization known in this country as the Society for the Prevention of Cruelty to Animals, a humane society. Their attention should be called to the granite block. There is not a more cruel or more inhuman thing over which horses can travel than a granite street. After a granite street has been down for five years, the top becomes rounded, and every step the horse takes is a short, sharp slip, bruising every joint and ruining the horse. I am not going to take up much more time, but there is one thing that I want to impress upon every man and beg every man's influence in this Association, and that is, to see that the specifications of the National Brick Manufacturers' Association are adopted and from time to time that they be carefully and skillfully carried out. We have not written them in a hurry, we did not write them in an hour, we did not write them in a week, we did not write them in a year; it has taken fifteen years of hard study to determine just what was best, and when we came before you with these specifications two or three years ago, we knew what we were talking about, and we haven't a word to take back since they were written. I am going to read you from a little circular issued by a number of brick manufacturers of Indiana which will echo no doubt the sentiments of all the paving brick manufacturers of the United States. It was addressed to the Municipal Convention which met in our city of Terre Haute last year. We called the attention of that Municipal Association to a few points of failure not because of our specifications, but by reason of a lack of skill in fulfilling the same.

"The concrete foundation is not smoothly finished.

"The true grade is not maintained by the concrete surface.

"There must be two inches of sand cushion.

"The rolling is attempted with other than a five-ton steam roller.

"The rolling is often so slight that the brick stand in the street without support. The rolling must be so thorough that no further compaction can be possible."

Gentlemen who are interested in the compaction and rolling of the street, I should like as opportunity is offered that you examine what is shown in this specimen here, by the perfect compaction and rolling of the street. You can see it was driven in the sand about one inch by the rolling and compaction.

"More disaster comes to a brick street from the want of properly applying the filler than from any other cause.

"A failure to comply with a single direction will easily take away five years of life of a street.

"Do not permit a greater amount of filler mixed in one batch than recommended—that alone will spoil the job.

"Let the man with the scoop take the mixture from the lower side of the box. Have the man who stirs the mixture stand at the lower end of the box. Let the box be immediately adjacent to the work. The man with the scoop should move but three or four steps at most from the box. Never allow the mixture to be poured or dumped on the street from the box. After going to all the trouble to get a street that will last a generation, do not let the cement bond be broken by using it short of ten days and thus throw away half your money before spending it." (Prolonged applause.)

D. J. Christopher, Chicago, Ill.: Having had the pleasure of seeing Mr. Purington "sweat blood" and the misfortune of being a brick engineer from the city of Chicago, I wish to ask a few questions and make a suggestion. On your two-inch sand cushion, would you recommend two inches of sand right up against the street railway rail, or would you recommend one inch where that concrete foundation is brought to a line. As a rule in putting in a street where there is a street car rail, they have a gauge that is run along the rail, andI have found in a number of places that the sand would shift down into that rail, and let the brick down under the rail, practically a quarter of an inch below the top of it. Again I would like to ask whether it is a benefit to have a space for the cement filler. For instance, some people have devised a patent or something similar to keep the brick apart. It has been a question in my mind whether it is a benefit to have these projections or not. As has been said by Mr. Blair, the brick men are bashful. And it has been suggested that a number of these pamphlets or specifications be printed and sent out broadcast. Now, if you want to do some good work, I

think it will be a good idea for you paving brick men to form an inner organization, the object of which would be to go into a city where they are about to do some paving and get contractor's privileges of putting down a block of brick pavement, according to your specifications, and show them how you would lay a first-class brick pavement. There are a great many people who do not believe that you can lay a good brick pavement. In Chicago, in the department in which I am connected, I am called a crank on brick pavement; the rest of the department are against me. Some favor asphalt because it is nice to ride over in an automobile or on a bicycle. They say brick pavement will not stand. Brick pavements in Chicago have never had a fair deal, and I think it would be a good idea for the paving brick manufacturers of this country to form themselves into an organization and send out their little specifications and pamphlets and then go into a city and say, "Look here, gentlemen, we will put you down a block of pavement under our specifications, and we will prove to you that you don't know how to lay a brick pavement." (Applause.)

D. V. Purington: There is no doubt in my mind but that a campaign of education would prove very beneficial, and this should be extended to the instruction of those who have charge of the tearing up and replacing of pavements for the purpose of repairing gas and water pipes or the laying of electric conduits, etc. With proper care, a brick pavement can be taken up and replaced without injury, but the proper care is seldom or never exercised and many a good brick street is ruined by careless and bungling work of repair gangs. I think in one block in the city of Chicago the brick pavement has been opened sixteen times, and as a result it is in a miserable condition. There is another block of pavement that has been down nine years and has never been touched from the time it was laid. There has not been any repair on it and the brick show little or no wear at all. Another block near by has been opened up twenty times or more, and is now uneven and all worn out; there is no difference in the quality of the brick, no difference in the method of construction of the pavement. One block has gone to demnition bow-wows and the other is as perfect as when put down. Prof. Baker, in referring to concrete foundations, mentioned the small stones that are frequently left on the surface. I think those of you who are at all familiar with the appearance of a concrete foundation of a street after it is prepared for the sand foundation, will recall that there are little knobs all over it varying in extent from a quarter of an inch below the grade to an inch above

it. Now, with a one-inch cushion of sand on a street prepared that way, the chances are that one-half of the brick will rest on these projections from a concrete foundation. I believe it is universally conceded by those who have studied the question that not less than two inches of sand should be allowed for a sand cushion. It is impossible with less than that depth of sand to get the brick sufficiently above the foundation so they will not come in contact with it or with these knobs and pebbles. The authorities of Chicago have become convinced that two inches of sand is necessary and have changed their specifications accordingly. This makes a brick pavement comparatively noiseless. I can fully and heartily endorse every item in Prof. Baker's able paper, save one. He says he wants the pavements narrow and long; we brickmakers want them *wide* and *long*. (Laughter.)

Just a word regarding the filler and I am through. I am convinced that the value of a brick pavement depends very largely on the quality of the filler used and the care with which it is applied. A good cement filler used carefully with a No. 1 paving brick insures a perfect pavement. A poor cement filler, or even a good cement filler, carelessly applied, results in a very indifferent pavement. I know from observation that many of our streets in the West, paved with the best quality brick, and the best possible foundation, are spoiled by a poor filler, or by the careless and improper use of a good filler. In our own interests as manufacturers we should insist on the skillful use of a good filler, for without it we cannot hope for a first-class pavement. I would really prefer a good sand filler to a poor cement filler. I know that some members of this Association consider our Indiana Vice-President a little cranky on the subject of fillers, but I am free to say that if there were more men like Mr. Blair actively espousing the cause of brick pavements and insisting on the greatest possible care in every detail of construction, the whole paving brick industry would be greatly benefited, and brick streets would grow rapidly in public favor. The brick streets of Terre Haute afford a fine object lesson in this connection. I am certain that the superior character of the Terre Haute pavements is due to the method of construction that is followed there. We may well bear this in mind, for what has been done there can be done in any other city, if the paving contractor will only exercise the same care and intelligence.

Mr. W. P. Blair: At the risk of justifying the intimation that I am a bit cranky, I wish to emphasize a little farther *regarding the filler.*

There is no good reason why we should accept anything other

than the best, because forsooth, that which is conceded the best is sometimes found difficult to obtain. Have we not just taxed our brain with intense interest with Prof. Orton's technical demonstration to advance one step farther in perfect burning? Do we not hold tenaciously to every single item to perfect manufacturing? Do we give up a method in manufacture we know reaches the best results because we are compelled to teach it to unskilled help? No.

It is right that our whole advance should be without a step backward anywhere. In the long age from the pottery of the Montezumas to the Rookwood on yonder hill many were the halts, but just now we can't stop; there is too much of a push behind us; we must go forward. There is nothing difficult about applying the filler correctly. Let the directions be insisted on, if a poor cement filler—a pitch or tar filler, a sand filler, all are in the same class—poor at best. But the cement filler, properlv mixed, applied, and of quality demanded is always and in all climes the best.

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